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⑭発明の名称　プラズマ処理装置

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明　細　書

1　発明の名称　プラズマ処理装置

2　特許請求の範囲

1.処理用気体の供給系と排出系に接続する反応槽内に上，下部電極を相対向するように設け、該両電極間に前記気体のプラズマを発生させ、該プラズマにより前記下部電極上に載置した処理基板をエッチングするプラズマ処理装置において、該下部電極内に処理基板を加熱または冷却する流体の導管および下部電極と処理基板との間に熱伝導用圧力気体を導入する導管を埋設し、上部電極および反応槽の上壁と側壁に空室をそれぞれ設け、該各空室内に温度制御された流体を循環させ、前記処理基板、両電極および反応槽内壁を同一温度に保持するようにしたことを特徴とするプラズマ処理装置。

3　発明の詳細な説明

〔発明の利用分野〕

本発明は処理基板、例えば半導体基板（以下ウエハと称す）などの試料をプラズマエッチングするプラズマ処理装置に関するものである。

〔発明の背景〕

従来のこの種プラズマエッチング装置は、例えば特開昭58-153332号公報に記載のように、ウエハを載置した電極の温度を低温に設定してレジストの劣化を防ぐと共に、該電極に対設した電極および反応槽の内壁の温度を、前記電極（ウエハ載置）の温度より高温に設定して真空排気することにより、前記対向電極の表面上および反応槽内壁面上に反応生成物が付着しないようにしたものである。

ところが、例えばAlエッチングの場合、エッチングガスとして塩素を含むガスを用いるため、反応生成物として$AlCl_3$（三塩化アルミニウム）が発生する。該$AlCl_3$は蒸気圧が低いため、冷却された電極および電極上に載置したウエハ表面上に付着するので、エッチレート、選択性およびサイドエッチなどのエッチング特性の再現性を低下させるという問題があつた。

上記問題点を解消するため、2週間に1回程

置は反応槽を開放し、電極などをクリーニングしなければならないから多大の手数を要するばかりでなく、反応槽内を大気に開放するため、空気中のゴミおよび水分が反応槽内に侵入し、エッチング特性に悪影響を及ぼすという難点がある。

また、クリーニングは一般に純水を含ませた布などによりふき取つて行うが、クリーニング後に水分が残つていると、エッチング特性に悪影響を及ぼす恐れがある。

〔発明の目的〕

本発明は上記のような従来技術の問題を解消し、ウエハ載置電極，対向電極および反応槽を個別に温度制御して温度分布を均一化することにより、エッチング中に生成されるプラズマ重合膜、反応生成物のウエハへの付着および反応槽のクリーニング作業を低減することを目的とするものである。

〔発明の概要〕

本発明は上記目的を達成するために、ウエハ裏面と該ウエハを載置する下部電極との間に熱伝導用圧力気体を導入すると共に、下部電極内に加熱または冷却用の恒温流体を循環させ、また上部電極および反応槽の上壁と側壁の内部に恒温の流体を循環させるように構成し、ウエハ上．下部電極および反応槽を同一温度に保持するようにしたことを特徴とする。

〔発明の実施例〕

以下、本発明の一実施例を図面について説明する。

第1図において、処理基板（以下、ウエハと称す）1は支持台7上に絶縁部材8を介して取付けられた下部電極2上に後述する押え板60を介して載置されている。該下部電極2内には導管3，4が連設され、該導管3は設定温度の流体の供給源5に連通し、導管4はウエハ1の裏面と下部電極2の上面との間に連通すると共に、マスフローコントローラ51と真空計32に接続する気体だめ6に連通している。該気体だめ6には、処理用ガスボンベ（図示せず）から供給された熱伝導用圧力気体25が圧力調整弁50およびコントローラ51を介して供給される。

上記支持台7は、反応槽9の下壁11にOリング21Bを介して気密に取付けられたガイド15内に、Oリング21Cを介して摺動可能に収納されており、駆動源、例えばエアシリンダ67（第2図）により上下動される。

上記反応槽9は、内壁12A，外壁12Bおよび該両壁12A，12B間に形成された空室12Cからなる側壁12と、該側壁12の上，下部にOリング21D，21Aを介して気密にそれぞれ結合された上壁10および下壁11とにより構成されている。該上壁10には、カバー19により覆われた空室20が設けられると共に、導管16A，16B，17が連設され、かつ導管16A，16Bに連通する空室18を設けた電極本体14と、複数個の噴出孔15aおよび前記導管17に連通する空室15bを設けた噴出部材15とからなる上部電極13が気密に取付けられている。前記空室20は連結管22，23を介して前記導管16Bおよび側壁12の空室12Cにそれぞれ連通されている。

前記押え板60は第2図に示すように、該押え板60の円周上に交互に配置されたボルト61，62に取付けられた環状板ばね63を介して反応槽の下壁（図示せず）に取付けられている。該押え板60とウエハ1との間に介設した緩衝材64は、押え板60とホルダ65により挟持されており、該ホルダ65はボルト61により環状板ばね63と共締めされた座66および押え板60により挟持されている。

次に上記のような構成からなる本実施例の動作について説明する。

下部電極2上に載置されたウエハ1は、支持台7をエアシリンダ67により上昇させることにより、押え板60に当接して保持・固定される。この際、環状ばね63は、ウエハ1を適正な力で押圧するように形状と寸法が設定されている。また、前記ウエハ1と下部電極2との間に、気体だめ6（第1図）から熱伝導用圧力気体25が導入されるが、押え板60によりウエハ1の外周

から前記圧力気体25が漏れるのを抑制されるから、該圧力気体は適正な圧力に保持される。

一方、反応槽9内は排気系40により低圧まで排気され、調整系42および真空計41により規圧に保持される。この状態で処理気体である塩素系ガス、例えばCCl_4（四塩化炭素）24が、上部電極13の導管17と空室15bを経て噴出孔15から反応槽9内に供給される。

ついで、下部電極2および上部電極15間には、高周波電源43により高周波が印加され、反応槽9内の処理気体はプラズマ状態となり、このプラズマによりウエハ1はエッチングされる。該エッチング時にウエハ1は、プラズマにさらされるから、その温度が上昇する。しかし、ウエハ1と下部電極2との間に導入された熱伝導用圧力気体の熱伝導により、熱の移動が盛んに行われるため、ウエハ1と下部電極2との伝熱性能を向上させることができる。

そして、ウエハ1および下部電極2間の温度差が小さくなり、下部電極2の温度を流体供給槽5および導管3を循環する流体により数十度に上昇させても、ウエハ1の温度をレジストの軟化しない温度に保つことができる。したがって、下部電極2の温度を制御することにより、ウエハ1の温度を任意に設定することができる。

上述した動作を行う場合、外部の恒温槽（図示せず）から供給される温度制御された流体50を、上部電極13内の導管16Aを経て空室18に導入させ、ついで導管16Bおよび連結管22を経て反応槽の上蓋10の空室20に導入させた後、連結管23を介して反応槽の側壁12の空室12Cに導入させる。このように前記流体50を上部電極13、反応槽9の上蓋10および側壁12内を順次に循環させることにより、反応槽9内を均一に、かつ約80°C程度に恒温化させた状態に保持する。

その理由は、下部電極2の温度を低温にしすぎると、ウエハ1に反応生成物が付着し易くなり、逆に120°C以上の高温になると、ウエハ1の表面上のエッチングマスク用レジストが軟化して劣化するので、前記両温度の中間温度（約80°C）が最適であるからである。

〔発明の効果〕

以上説明したように、本発明によれば、反応槽内部を最適の温度（約80°C）に保持することにより、プラズマ中で発生する反応生成物が処理基板，電極および反応槽へ付着するのを阻止することができる。したがつて、反応槽内部を常に清浄に保つことができるから、エッチング特性の再現性および半導体素子の信頼性を向上させることができる。

また、反応槽のクリーニング作業を低減させることにより、クリーニング作業工程を減少させると共に、プラズマ処理装置の稼動率を大幅に向上させることができる。

4　図面の簡単な説明

第1図は本発明のプラズマ処理装置の一実施例を示す断面図、第2図は第1図のウエハ押え部の断面図である。

1 — 処理基板　　2 — 下部電極

3，4，16A，16B — 導管

9 — 反応槽　　10 — 上蓋

12 — 側壁　　12C，18，20 — 空室

13 — 上部電極　　50 — 温度制御流体

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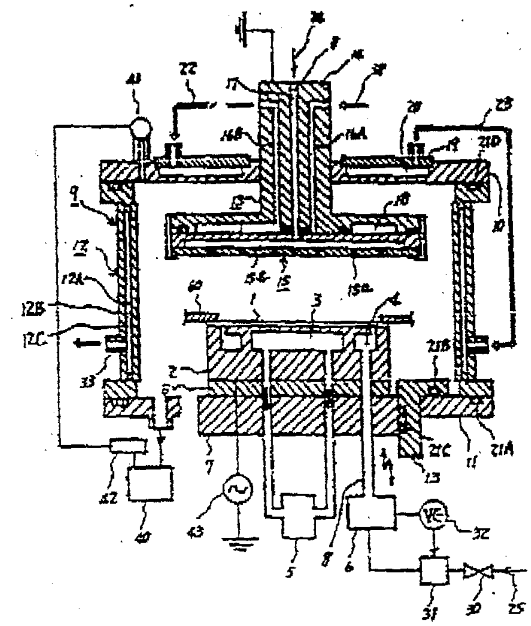
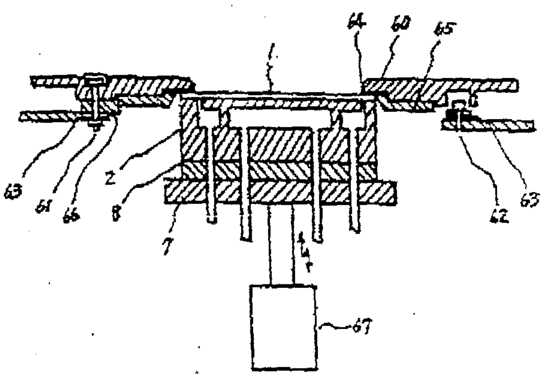
第 1 図



第 2 図



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PLASMA PROCESSING DEVICE

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[There are no amendments to this patent.]

Claim

1. A plasma processing device, in which upper and lower electrodes are provided in a manner so that they face each other within a reaction tank, which is connected to a supply system and an exhaust system of a processing gas, and a plasma of the aforementioned gas is generated between both of said electrodes

in order to perform etching to a processing substrate, which is mounted over the aforementioned lower electrode, by said plasma, characterized by the ducts for a fluid, which heats or cools the processing substrate, and the ducts, through which the heat-conducting pressure gas is introduced between the lower electrode and the processing substrate, being embedded within said lower electrode, empty chambers respectively being provided at the upper electrode and the upper wall and the side wall of the reaction tank, and the fluid, in which the temperature is controlled, being circulated through each of said empty chambers in order to maintain the aforementioned processing substrate, both electrodes, and the walls within the reaction tank at a constant temperature.

Detailed explanation of the invention

Industrial application field

The present invention concerns a plasma processing device which performs plasma etching to samples such as a semiconductor substrate (will be abbreviated as a wafer below), for example.

Background of the invention

As described in the official report for the Japanese Kokai Patent Application No. Sho 58[1983]-153332, for example, with an existing plasma etching device of this type, the temperature of an electrode, onto which a wafer is mounted, is set at a low temperature in order to prevent the deterioration of the resist, and the temperature of the electrode, which is provided opposite

from said electrode, and the temperature of the inner walls of the reaction tank are set higher than the temperature of the aforementioned electrode (mounted over the wafer), and a vacuum exhaust is obtained so that reaction products do not adhere onto the surface of the aforementioned counterelectrodes and onto the inner walls of the reaction tank.

However, gas that includes chloride is used as the etching gas during an Al etching, for example, and $AlCl_3$ (aluminum trichloride) is generated as a reaction product. The vapor pressure of said $AlCl_3$ is low, and it adheres onto the electrode that is cooled with water and at the surface of the wafer that is mounted over the electrode, and there is the problem of the reproducibility of the etching characteristics, such as the etch rate, selectivity, and side etching, for example, being reduced.

In solving the aforementioned problem, the reaction tank must be opened approximately once every 2 weeks, and the electrodes, for example, must be cleaned. Therefore, not only is tremendous labor required, but there is also a difficult problem of the etching characteristics being negatively affected when the inside of the reaction tank is opened to the air, and the dust and water contents in the air enter the reaction tank.

Also, cleaning is generally obtained by wiping with a cloth soaked in pure water, for example; however, there is a risk of the etching characteristics being negatively affected when water contents remain after cleaning.

Objective of the invention

The objective of this invention is to solve the problems in the existing technology described above and to reduce the

adhesion of plasma polymerized films and reaction products that are formed during etching onto the wafer as well as the cleaning operation of the reaction tank by controlling the electrode, onto which the wafer is mounted, counterelectrode, and the reaction tank at a constant temperature and by forming a uniform temperature distribution.

Abstract of the invention

In attaining the aforementioned objective, this invention is characterized by being structured in a manner so that a heat-conducting pressure gas is introduced between the back face of a wafer and a lower electrode, onto which said wafer is mounted. A heating or cooling constant temperature fluid also circulates within the lower electrode, and a fluid at a constant-temperature circulates through the upper electrode and within the upper wall and the side wall of the reaction tank in order to maintain the wafer, upper and lower electrodes, and the reaction tank at a constant temperature.

Application example of the invention

An application example of this invention will be explained in the figures below.

In Figure 1, a processing substrate (will be abbreviated as a wafer below) (1) is mounted over a lower electrode (2), which is attached onto a supporting table (7) through an insulating member (8), through a pressure plate (60), which will be described later. Ducts (3) and (4) are embedded within said lower electrode (2). Said duct (3) communicates with a supply

source (5) of a fluid at a constant temperature. The duct (4) communicates with a [space] between the back face of the wafer (1) and the upper face of the lower electrode (2), and also communicates with a gas reservoir (6), which is connected to a mass flow controller (31) and a vacuum gauge (32). Heat conducting pressure gas (25), which is supplied from a processing gas bomb (not shown in the figure), is supplied to said gas reservoir (6) through a pressure controlling valve (30) and a controller (31).

The aforementioned supporting table (7) is stored within a guide (13), which is airtightly attached to a lower wall (11) of the reaction tank (9) through an O-ring (21B), through an O-ring (21C) in a manner so that it can slide and move, and it vertically moves by means of a driving source, such as an air cylinder (67) (Figure 2), for example.

The aforementioned reaction tank (9) consists of: an inner wall (12A); outer wall (12B); side wall (12), which consists of an empty chamber (12C) formed by both of said walls (12A) and (12B); and upper wall (10) as well as lower wall (11), which are respectively connected airtightly to the upper and lower parts of said side wall (12) through O-rings (21D) and (21A). An empty chamber (20), which is covered by a cover (19), is provided at said upper wall (10), and ducts (16A), (16B), and (17) are also embedded, and an upper electrode (13), which consists of a main electrode body (14), which is provided with an empty chamber (18) that communicates with the ducts (16A) and (16B), and an exhausting member (15), which is provided with multiple exhaust holes (15a) and an empty chamber (15b) which communicates with the aforementioned duct (17), are also airtightly attached. The aforementioned empty chamber (20) communicates with the

aforementioned duct (16B) and the empty chamber (12C) of the side wall (12) respectively through connecting pipes (22) and (23).

As illustrated in Figure 2, the aforementioned pressure plate (60) is attached to the lower wall of the reaction tank (not shown in the figure) through a circular plate spring (63), which is attached to bolts (61) and (62) that are alternately arranged over the circumference of said pressure plate (60). A cushioning member (64), which is inserted between said pressure plate (60) and the wafer (1), is held by the pressure plate (60) and the holder (65), and said holder (65) is held by a seat (66), which is fastened together with the circular plate spring (63) by the bolt (61), and the pressure plate (60).

Next, the operation of this application example having the structure described above will be explained.

The wafer (1), which is mounted over the lower electrode (2), makes contact with the pressure plate (60), and then is held and fixed by elevating the supporting table (7) by means of the air cylinder (67). The shape and the size of the circular spring (63) is established so that it presses against the wafer (1) with a proper force. Also, heat-conducting pressure gas (25) is introduced from the gas reservoir (6) (Figure 1) between the aforementioned wafer (1) and the lower electrode (2), and a proper pressure of said pressure gas can be maintained because leakage of the aforementioned pressure gas (25) from the outer circumference of the wafer (1) can be prevented by the pressure plate (60).

On the other hand, the inside of the reaction tank (9) is exhausted to a low pressure by an exhaust system (40), and it is maintained at a constant pressure by a controlling system (42) and a vacuum gauge (41). In this condition, chloride group gas,

such as CCl_4 (carbon tetrachloride) (24), which is a processing gas, is supplied into the reaction tank (9) through the exhaust holes (15) by way of the duct (17) and the empty chamber (15b) of the upper electrode (13).

Successively, a high-frequency wave is applied from a high-frequency power source (43) between the lower electrode (2) and the upper electrode (13), the state of the processing gas within the reaction tank (9) is changed into a plasma, and the wafer (1) is etched by this plasma. The wafer (1) is exposed to the plasma during said etching, and its temperature increases. However, the heat actively moves because of the heat conduction of the heat-conducting pressure gas that is introduced between the wafer (1) and the lower electrode (2), and the heat conductivity between the wafer (1) and the lower electrode (2) can be improved.

Then, the difference in temperature between the wafer (1) and the lower electrode (2) is reduced, and the temperature of the wafer (1) can be maintained at a temperature at which the resist is not softened even when the temperature of the lower electrode (2) is increased by several tens of degrees by the fluid that circulates through the fluid supply source (5) and the duct (3). Accordingly, the temperature of the wafer (1) can be optionally established by controlling the temperature of the lower electrode (2).

When obtaining the operation described above, the fluid (50), which is supplied from a constant temperature tank (not shown in the figure) at the outside and in which the temperature is controlled, is guided into the empty chamber (18) by way of the duct (16A) within the aforementioned electrode (13), it is successively introduced into the empty chamber (20) at the upper wall (10) of the reaction tank by way of the duct (16B) and the

connecting pipe (22), and it is then introduced into the empty chamber (12C) at the side wall (12) of the reaction tank through the connecting pipe (23). The aforementioned fluid (50) is successively circulated through the upper electrode (13) and the upper wall (10) and the side wall (12) of the reaction tank (9) in this way, and a state within the reaction tank (9) at a uniform and constant temperature of approximately 80°C as well can be maintained.

The reason for this is that reaction products easily adhere onto the wafer (1) when the temperature of the lower electrode (2) is set too low, and the resist for the etching mask on the surface of the wafer (1) is softened and deteriorates when, on the other hand, the temperature becomes high at above 120°C. Therefore, the intermediate temperature of both the aforementioned temperatures (approximately 80°C) is optimal.

Effect of the invention

As explained above, the adhesion of reaction products that are generated in the plasma onto the processing substrate, electrode, and the reaction tank can be prevented by maintaining an optimal temperature (approximately 80°C) within the reaction tank in this invention. As a result, the inside of the reaction tank can always be maintained clean, and the reproducibility of the etching characteristics and reliability in the semiconductor element can be improved.

Also, the number of cleaning operational processes can be reduced, and the operability of the plasma processing device can also be drastically improved by reducing the cleaning operation of the reaction tank.

Brief description of the figures

Figure 1 is a cross-sectional diagram illustrating an application example of the plasma processing device of the present invention. Figure 2 is a cross-sectional diagram of a wafer pressing part of Figure 1.

1.	Processing substrate
2.	Lower electrode
3., 4, 16A, 16B	Ducts
9.	Reaction tank
10.	Upper wall
12.	Side wall
12C, 18, 20	Empty chambers
13.	Upper electrode
50.	Temperature-controlling fluid

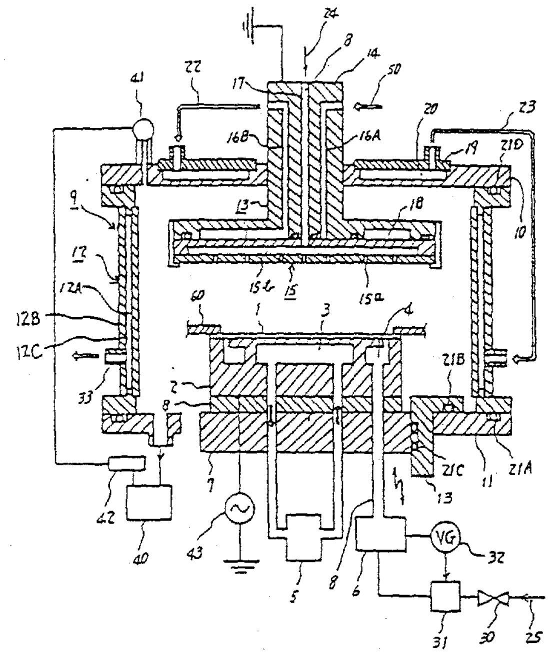

Figure 1

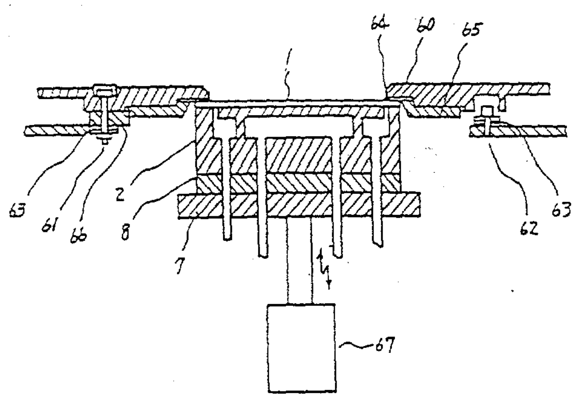

Figure 2